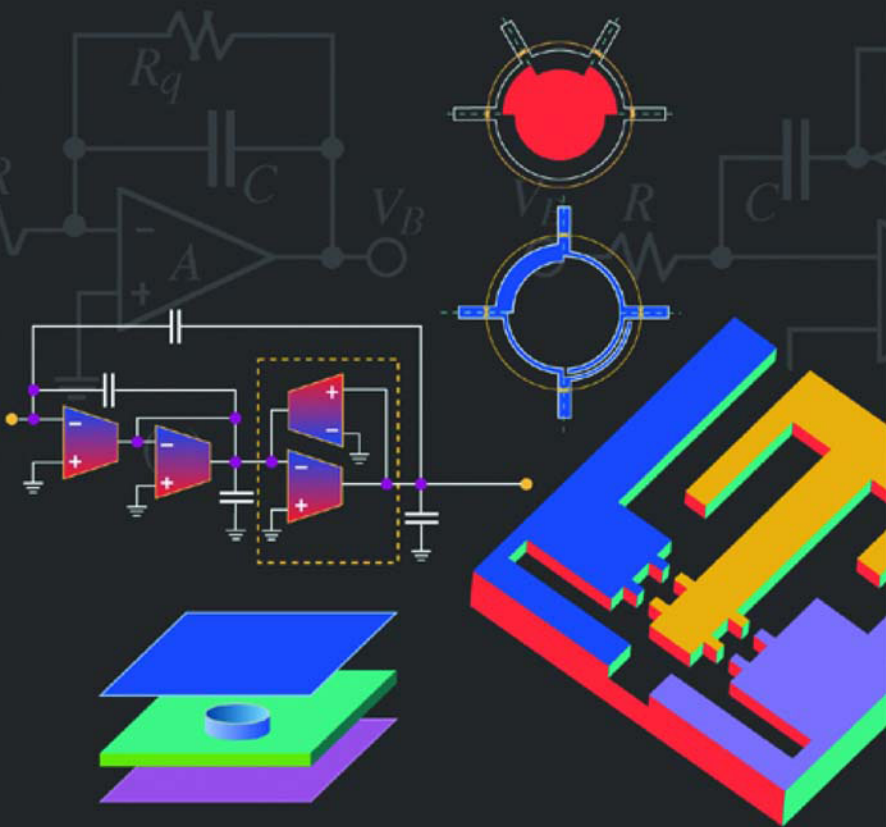




WAI-KAI CHEN

Editor-in-Chief

THE ELECTRICAL ENGINEERING HANDBOOK



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THE ELECTRICAL ENGINEERING HANDBOOK

WAI-KAI CHEN

EDITOR



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Preface

Purpose

The purpose of *The Electrical Engineering Handbook* is to provide a comprehensive reference work covering the broad spectrum of electrical engineering in a single volume. It is written and developed for the practicing electrical engineers in industry, government, and academia. The goal is to provide the most up-to-date information in classical fields of circuits, electronics, electromagnetics, electric power systems, and control systems, while covering the emerging fields of VLSI systems, digital systems, computer engineering, computer-aided design and optimization techniques, signal processing, digital communications, and communication networks. This handbook is not an all-encompassing digest of everything taught within an electrical engineering curriculum. Rather, it is the engineer's first choice in looking for a solution. Therefore, full references to other sources of contributions are provided. The ideal reader is a B.S. level engineer with a need for a one-source reference to keep abreast of new techniques and procedures as well as review standard practices.

Background

The handbook stresses fundamental theory behind professional applications. In order to do so, it is reinforced with frequent examples. Extensive development of theory and details of proofs have been omitted. The reader is assumed to have a certain degree of sophistication and experience. However, brief reviews of theories, principles, and mathematics of some subject areas are given. These reviews have been done concisely with perception. The handbook is not a textbook replacement, but rather a reinforcement and reminder of material learned as a student. Therefore, important advancement and traditional as well as innovative practices are included.

Since the majority of professional electrical engineers graduated before powerful personal computers were widely available, many computational and design methods may be new to them. Therefore, computers and software use are thoroughly covered. Not only does the handbook use traditional references to cite sources for the contributions, but it also contains

relevant sources of information and tools that would assist the engineer in performing his/her job. This may include sources of software, databases, standards, seminars, conferences, and so forth.

Organization

Over the years, the fundamentals of electrical engineering have evolved to include a wide range of topics and a broad range of practice. To encompass such a wide range of knowledge, the handbook focuses on the key concepts, models, and equations that enable the electrical engineer to analyze, design, and predict the behavior of electrical systems. While design formulas and tables are listed, emphasis is placed on the key concepts and theories underlying the applications.

The information is organized into nine major sections, which encompass the field of electrical engineering. Each section is divided into chapters. In all, there are 72 chapters involving 108 authors, each of which was written by leading experts in the field to enlighten and refresh knowledge of the mature engineer and educate the novice. Each section contains introductory material, leading to the appropriate applications. To help the reader, each article includes two important and useful categories: defining terms and references. *Defining terms* are key definitions and the first occurrence of each term defined is indicated in boldface in the text. The *references* provide a list of useful books and articles for following reading.

Locating Your Topic

Numerous avenues of access to information contained in the handbook are provided. A complete table of contents is presented at the front of the book. In addition, an individual table of contents precedes each of the nine sections. The reader is urged to look over these tables of contents to become familiar with the structure, organization, and content of the book. For example, see Section VII: Signal Processing, then Chapter 7: VLSI Signal Processing, and then Chapter 7.3: Hardware Im-

plementation. This tree-like structure enables the reader to move up the tree to locate information on the topic of interest.

The Electrical Engineering Handbook is designed to provide answers to most inquiries and direct inquirer to further sources and references. We trust that it will meet your need.

publishers, and most of all the contributing authors. I particularly wish to acknowledge my wife, Shiao-Ling, for her patience and support.

Wai-Kai Chen
Editor-in-Chief

Acknowledgments

The compilation of this book would not have been possible without the dedication and efforts of the section editors, the

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CIRCUIT THEORY

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Circuit theory is an important and perhaps the oldest branch of electrical engineering. A circuit is an interconnection of electrical elements. These include passive elements, such as resistances, capacitances, and inductances, as well as active elements and sources (or excitations). Two variables, namely voltage and current variables, are associated with each circuit element. There are two aspects to circuit theory: **analysis and design**. Circuit analysis involves the determination of current and voltage values in different elements of the circuit, given the values of the sources or excitations. On the other hand, circuit design focuses on the design of circuits that exhibit a certain prespecified voltage or current characteristics at one or more

parts of the circuit. Circuits can also be broadly classified as **linear or nonlinear circuits**.

This section consists of five chapters that provide a broad introduction to most fundamental principles and techniques in circuit analysis and design:

- Linear Circuit Analysis
- Circuit Analysis: A Graph-Theoretic Foundation
- Computer-Aided Design
- Synthesis of Networks
- Nonlinear Circuits.